<u>**APPEAL BRIEF UNDER 37 C.F.R. § 41.37**</u>

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Kie Y. Ahn et al. | Examiner: Colleen E. Rodgers

Serial No.: 09/945,535 | Group Art Unit: 2813

Filed: August 30, 2001 | Docket: 1303.026US1

For: HIGHLY RELIABLE AMORPHOUS HIGH-K GATE OXIDE ZrO2

APPEAL BRIEF UNDER 37 CFR § 41.37

Mail Stop Appeal Brief- Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

The Appeal Brief is presented in support of the Notice of Appeal to the Board of Patent Appeals and Interferences, filed on July 21, 2008, from the Final Rejection of claims 1-2, 6-10, 14-15, 19-23, 27-31, 35-37, 51-52, 54-56 and 62 of the above-identified application, as set forth in the Final Office Action mailed on April 21, 2008.

The Commissioner of Patents and Trademarks is hereby authorized to charge Deposit Account No. 19-0743 in the amount of $510.00 which represents the requisite fee set forth in 37 C.F.R. § 41.20(b)(2). The Appellants respectfully request consideration and reversal of the Examiner's rejections of pending claims.

1. REAL PARTY IN INTEREST

The real party in interest of the above-captioned patent application is the assignee, MICRON TECHNOLOGY, INC..

2. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences known to Appellant that will have a bearing on the Board's decision in the present appeal.

3. STATUS OF THE CLAIMS

The present application was filed on December 30, 2001 with claims 1-61. A resetirction requirement dated March 18, 2002 resulted in the cancellation of claims 38-61. A first Office Action mailed June 5, 2002, and fourteen subsequent Office Actions resulted in various amendments to the claims and the cancellation of claims 3-5 and 10-37. A Final Office Action (hereinafter "the Final Office Action") was mailed May 19, 2004. Claims 1-2and 6-9 stand fifteen times rejected, remain pending, and are the subject of the present Appeal.

4. STATUS OF AMENDMENTS

No amendments have been made subsequent to the response to the Final Office Action dated April 21, 2008. The response dated June 23, 2008 contained no claim amendments, canceled claims 10, 14-15, 19-23, 27-31, 35-37, 51-52, 54-56 and 62 without prejudice, and added no claims. These changes were entered in the Advisory Action dated July 1, 2008. As a result, claims 1-2 and 6-9 are now pending in this appeal.

5. SUMMARY OF CLAIMED SUBJECT MATTER

Aspects of the present inventive subject matter include, but are not limited to methods of forming devices with a highly reliable amorphous high-K gate oxide ZrO_2.

The following independent claims include a page number, line number, figure number and reference number where the recited element may be found in the application as originally filed.

Independent Claim 1

1. A method of forming a gate oxide [Page 4, Ln 10, Fig 1, 140] on a transistor body region [Page 6, Ln 22, Fig 3a, 316], comprising:

evaporation depositing [Page 6, Ln 18, Fig 3a, 336] a substantially amorphous [Page 7, Ln 15, Fig 3a, 320] and 0.99999 pure single element [Page 7, Ln 8, Fig 3a, 320] metal layer directly contacting [Page 7, Ln 26, Fig 3b, 342 and 348] a single crystal [Page 6, Ln 4, Fig 3a, 316] semiconductor portion of the body region [Page 6, Ln 22, Fig 3a, 316] using electron beam evaporation [Page 6, Ln 18, Fig 3a, 336] at a temperature between 150 to 200 °C,[Page 7, Ln 28] the metal being chosen from the group IVB elements [Page 7, Ln 6] of the periodic table; and

oxidizing [Page 8, Ln 10, Fig 4a, 410] the metal layer to form a metal oxide layer [Page 8, Ln 11, Fig 4c, 450] directly contacting [Page 7, Ln 26, Fig 3b, 342 and 348] the body region, wherein the metal oxide layer is amorphous [Page 20, Ln 24] and has a smooth surface [Page 8, Ln 4, Fig 3b, 346] with a surface roughness variation of 0.6 nm [Page 10, Ln 3, Fig 3b, 346].

Independent Claim 9

9. A method of forming a gate oxide [Page 4, Ln 10, Fig 1, 140] on a transistor body region [Page 6, Ln 22, Fig 3a, 316], comprising:

evaporation depositing [Page 6, Ln 18, Fig 3a, 336] a substantially amorphous [Page 7, Ln 15, Fig 3a, 320] and 0.99999 pure single element [Page 7, Ln 8, Fig 3a, 320] metal layer directly contacting [Page 7, Ln 26, Fig 3b, 342 and 348] a single crystal semiconductor portion

of the body region using electron beam evaporation [Page 6, Ln 18, Fig 3a, 336] at a temperature between 150 to 200 °C [Page 7, Ln 28], the metal being chosen from the group IVB elements [Page 7, Ln 6] of the periodic table; and

oxidizing [Page 8, Ln 10, Fig 4a, 410] the metal layer using a krypton(Kr)/oxygen (O_2) mixed plasma [Page 8, Ln 17] process to form a metal oxide layer directly contacting [Page 7, Ln 26, Fig 3b, 342 and 348] the body region, wherein the metal oxide layer is amorphous and has a smooth surface [Page 8, Ln 4, Fig 3b, 346] with a surface roughness variation of 0.6 nm [Page 10, Ln 3, Fig 3b, 346].

This summary does not provide an exhaustive or exclusive view of the present subject matter, and Appellant refers to each of the appended claims and its legal equivalents for a complete statement of the invention.

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1-2, 6-7 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ma et al. (U.S. Patent No. 6,207,589) in view of Park (U.S. Patent No. 5,795,808) and Yano et al. (U.S. Patent No. 5,810,923).

Claims 8-9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ma et al. (U.S. Patent No. 6,207,589) in view of Park (U.S. Patent No. 5,795,808) and Yano et al. (U.S. Patent No. 5,810,923) as applied to claims 1-2, 6-7, 14-15, 19-20, 51-52, 56 and 62 above, and further in view of Moise et al. (U.S. Patent No. 6,211,035).

7. ARGUMENT

A) The Applicable Law under 35 U.S.C. §103(a)

The determination of obviousness under 35 U.S.C. § 103 is a legal conclusion based on factual evidence. See Princeton Biochemicals, Inc. v. Beckman Coulter, Inc., 411 F.3d 1332, 1336-37 (Fed.Cir. 2005). The legal conclusion, that a claim is obvious within §103(a), depends on at least four underlying factual issues set forth in Graham v. John Deere Co. of Kansas City, 383 U.S. 1, 17, 86 S.Ct. 684, 15 L.Ed.2d 545 (1966): (1) the scope and content of the prior art; (2) differences between the prior art and the claims at issue; (3) the level of ordinary skill in the pertinent art; and (4) evaluation of any relevant secondary considerations.

The test for obviousness under 35 USC § 103 must take into consideration the invention as a whole, which means that one must consider the particular problem solved by the combination of elements that defines the invention. *Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1143, 227 U.S.P.Q. 543, 551 (Fed. Cir. 1985). The Examiner can only rely on references which are either in the same field and that of the invention, or if not in the same field, the references must be "reasonably pertinent to the particular problem with which the inventor was concerned." *M.P.E.P.* § 2141(a) (citing *In re Oetiker*, 977 F.2d 1443, 24 U.S.P.Q.2d (BNA) 1443 at 1445 (Fed. Cir. 1992). The Examiner must also recognize and consider not only the similarities but also the critical difference between the claimed invention and the prior art. *In re Bond*, 910 F.2d 831, 834, 15 U.S.P.Q.2d (BNA) 1566, 1568 (Fed. Cir. 1990) *reh'g denied,* 1990 U.S. App. LEXIS 19971 (Fed. Cir. 1990).

B) Discussion of the rejection of claim 1 under 35 U.S.C. § 103(a) as being unpatentable over Ma et al. (U.S. Patent No. 6,207,589) in view of Park (U.S. Patent No. 5,795,808) and Yano et al. (U.S. Patent No. 5,810,923).

Claims 1-2, 6-7 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ma et al. (U.S. Patent No. 6,207,589) in view of Park (U.S. Patent No. 5,795,808) and Yano et al. (U.S. Patent No. 5,810,923).

The cited reference of Ma suggests use of a high dielectric constant film "that remains amorphous at relatively high annealing temperatures" by use of "either Zr or Hf, doped with a trivalent metal, such as Al". Ma does not fairly suggest the use of pure metals. That Ma clearly suggests the use of a trivalent metal alloy maybe found in the Abstract and in virtually every paragraph and in every independent claim of Ma. (See for example col. 1, lines 35, 41, 53, 60, 61, 64; col. 2, lines 2, 21, 24, 27, 29, 37, 39, 43, 49, 61, 68; col. 3, lines 3, 13, 34, 36, 45, 50, 61, 63; col. 4, lines 1, 5, 14, 20, 21, 28, 29, 46, 57, 64; col. 5, lines 44, 53, 62, 65 (listing the range of 0-50%); col. 6, lines 21, 23, 26, 34, 42, 46, 51, 60; col. 7, lines 6, 9, 11, 17, 21, 22, 31, 47, 65; col. 8, lines 20, 25, 27, 31, 37, 56, 61, 67; col. 9, lines 6, 8, 13, 17; and col. 10, line 18). Appellant submits that the cited Ma reference would be clearly understood by one of ordinary skill in the art to strongly suggest the use of heavily doped metal layers to prevent crystallization of the metal during anneal.

Appellant respectfully submits that the Examiner is incorrect to suggest that Ma discloses "a substantially pure single metal layer" (see page 3 of the Office Action dated April 21, 2008) and pointing to col. 2, lines 65-67; col. 3, lines 53-55 and 60-62; and col. 5, lines 65-66" as proof of the suggestion of pure metal. The cited sections of the Ma reference are taken out of context and mischaracterize the reference teachings. For example, the section of Ma cited by the Examiner, col. 2, lines 65-67, recites "a metal selected from the group consisting of zirconium (Zr) and hafnium (Hf), and oxygen", but actually is the second half of a sentence clearly teaching a "film including a trivalent metal, such as aluminum (Al), scandium (Sc), or lanthanum (La), ..." and then concluding with the incomplete portion cited by the Examiner to indicate that only a pure metal is being taught.

Further, the Examiner cites col. 3, lines 53-55 of Ma, to support the contention that Ma suggests a single pure metal. The cited section actually recites "In short, it was discovered that doping a ZrO2 film, with a trivalent metal such as Al, results in that film remaining amorphous under typical (high temperature) processing conditions", which clearly teaches an alloy and a non-pure metal, specifically stating the discovery of doping metal. Appellant submits that the reference fairly teaches deposition of Zr or Hf with up to 50% of a trivalent metal such as aluminum, with 25% being taught as the preferred level. This teaching of the importance of the use of alloyed metal, which is an extremely impure metal, is repeated throughout the cited reference. Ma teaches that doping with trivalent materials causes the film to "resist the formation of a crystalline structure, interfaces to adjacent films have fewer irregularities", and "the film can be made thin to support smaller transistor geometries, while the surface of the channel region can be made smooth to support high electron mobility". The figures show the properties, such as IV characteristics, leakage currents, time dependent dielectric breakdown voltages, and time to failure plots, of trivalent doped metals with up to 50% trivalent, and show that low doping levels have worse results.

As a further example of the incorrect characterization of the Ma reference, the Examiner points to col. 3, lines 60-62 to prove that the metal is pure. The cited section should properly include the preceding sentence which states "The present invention is a thin film having a high dielectric constant, with respect to silicon dioxide, which comprises a trivalent metal, a metal selected from the group consisting of zirconium (Zr) and hafnium (Hf), and oxygen. The high dielectric film is resistant to crystallization, remaining amorphous for forming a smoother surface. The trivalent metal is selected form the group consisting of aluminum (Al), scandium (Sc), and lanthanum (La)". Appellant submits that this again strongly suggest an alloy, and does not suggest a pure metal of any sort.

As another example, the Examiner cites col. 5, lines 65-66" as proof of the suggestion of pure metal in Ma. The cited section states "The percentage of Al, or other trivalent metal, in film 56 is in the range of approximately 0 to 50%", which is said to suggest that the lower end of the range of 0% is taught. However, the next sentence in this paragraph states "Preferably, the percentage of Al in film 56 is approximately 25%", which in conjunction with the use of the term alloy and trivalent metal in virtually every preceding paragraph is submitted to clearly teach

away from a pure metal. The figures show the improvement to be found by use of 25% alloys of trivalent metal, and no one of ordinary skill in the art would be motivated to use a pure metal (i.e., 0% alloy) by reading this reference strongly teaching away from pure metals.

Appellant respectfully submits that Ma teaches heavily doped metal layers. Ma states at col. 2, lines 58-62 that it "would be advantageous if improved high-k dielectric materials could be formed by simply doping ... additional elements" into metal oxides. At col. 2, lines 1-3 Ma suggests doping a high-k dielectric with heavy amounts of another material to prevent "the formation of an interfacial SiO_2 layer" (also see col. 1 lines 45-47) by the addition of a "trivalent metal" at around 50% (col. 2, lines 1-3). Ma is believed to teach against the use of pure metals, and further the issue of metal purity is not mentioned.

The cited reference of Park is used by the Examiner to show that sputtering and evaporation are art recognized equivalents. Appellant submits that the present application teaches why the use of sputtering is NOT equivalent to evaporation in the present situation, and the use of sputtering may cause a rough surface and crystal damage, as shown in figure 2b and discussed on page 3, lines 17-23, and page 7, line 22. This damage may increase the leakage current through the gate oxide by a factor of ten times for each 0.1 nm increase in roughness (see page 3, line 1). Park teaches away from the use of evaporation.

The cited reference of Yano is used by the Examiner to show that the deposition of a pure metal, the oxidation of metal, and that smooth metal oxide surfaces are known. Appellant submits that Yano teaches the deposition of an oxide from a metal alloy having 75% rare earth metal (col. 8, line 33) in a vacuum chamber with an oxidizing gas (col. 8, line 57) to form an epitaxial oxide layer. Thus Yano teaches away from pure metals and amorphous dielectrics, and thus does not cure the failure of the other references to suggest a pure metal. The Examiner is incorrect to suggest that Yano teaches an amorphous dielectric since amorphous is not mentioned and the term "epitaxial" means crystalline and is by definition not amorphous. Yano teaches against amorphous materials, against pure metals, and against direct contact of dielectric layers to semiconductor material.

Appellant respectfully disagrees with the Examiner's characterization of the teachings of the cited references. Ma suggests a heavily doped metal layer, and not a pure metal, but "either Zr or Hf, doped with a trivalent metal, such as Al". Ma states that the use of pure metals is a problem to be solved by the use of heavy doping with a trivalent metal, as is found in the abstract and in virtually every single paragraph and every independent claim. The Examiner is incorrect to suggest that Ma discloses "a substantially pure single metal layer".

Park does state that sputtering and evaporation are art recognized equivalents, but the present application shows that sputtering is a problem and not equivalent to evaporation. Thus, Park teaches away from the recited arrangement.

Yano does not teach deposition of a pure metal but rather a metal alloy having 75% rare earth metal (col. 8, line 33) in a vacuum chamber with an oxidizing gas (col. 8, line 57) to form an epitaxial oxide layer. Yano does not suggest a pure metal, and does not teach an amorphous dielectric but rather epitaxial dielectrics. Yano teaches away from amorphous materials, and against pure metals.

Appellant respectfully submits that the combination of Ma with Park and Yano fails to describe or suggest at least the claimed feature of "*...evaporation depositing a substantially amorphous and 0.99999 pure single element metal layer directly contacting a single crystal semiconductor portion of the body region using electron beam evaporation at a temperature between 150 to 200 °C, the metal being chosen from the group IVB elements of the periodic table; and oxidizing the metal layer to form a metal oxide layer directly contacting the body region, wherein the metal oxide layer is amorphous and has a smooth surface with a surface roughness variation of 0.6 nm...*" as recited in claim 1. The combination of cited references do not suggest pure metal, do not suggest a single metal and do not suggest direct contact to the single crystal semiconductor substrate. Appellant requests reconsideration of the rejection.

Dependent claims 2 and 6-8 are held to be patentable at least as depending from patentable base claims as shown above, since any claim depending from a nonobvious independent claim is also nonobvious. See M.P.E.P. § 2143.03. In view of the failure of the suggested combination of references to describe or suggest pure metal, amorphous oxide, or direct contact between the oxide and the substrate, Appellant requests this rejection under 35 U.S.C. § 103(a) be reconsidered and withdrawn.

C) Discussion of the rejection of claims 8-9 under 35 U.S.C. § 103(a) as being unpatentable over Ma et al. (U.S. Patent No. 6,207,589) in view of Park (U.S. Patent No. 5,795,808) and Yano et al. (U.S. Patent No. 5,810,923), and further in view of Moise et al. (U.S. Patent No. 6,211,035). .

Claims 8-9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ma et al. (U.S. Patent No. 6,207,589) in view of Park (U.S. Patent No. 5,795,808) and Yano et al. (U.S. Patent No. 5,810,923) as applied to claims 1-2, 6-7, 14-15, 19-20, 51-52, 56 and 62 above, and further in view of Moise et al. (U.S. Patent No. 6,211,035). Appellant traverses this rejection. Claims 10, 21 and 54 are cancelled herein.

Ma suggests a heavily doped metal layer, "either Zr or Hf, doped with a trivalent metal, such as Al" and not a pure metal. Ma states that the use of pure metals is a problem to be solved by the use of heavy doping with a trivalent metal, as is found in virtually every single paragraph.

Park suggests that sputtering and evaporation are art recognized equivalents, but the present application shows that sputtering is a problem and not equivalent to evaporation. Thus, Park teaches away from the recited arrangement.

Yano does not teach deposition of a pure metal but rather a metal alloy having 75% rare earth metal (col. 8, line 33) in a vacuum chamber with an oxidizing gas (col. 8, line 57) to form an epitaxial oxide layer. Yano does not suggest a pure metal, and does not teach an amorphous dielectric but rather epitaxial dielectrics. Yano teaches away from amorphous materials, and against pure metals.

The cited reference of Moise shows that annealing in an inert ambient such as krypton, and in conjunction with the oxidizing anneal of Ma are known. Appellant submits that the

teachings of Moise do not include the use of pure single metal layers and there is no motivation for one of ordinary skill in the art to make the proposed combine with Ma and the other references. Whether or not any possible motivation exists, the proposed combination still does not result in all the recited features of the present claims, such as the use of a single pure metal.

Appellant respectfully submits that the combination of Ma, Park, Yano and Moise, whether taken alone or in any combination, fails to describe or suggest at least the claimed feature of a "*...evaporation depositing a substantially amorphous and 0.99999 pure single element metal layer directly contacting a single crystal semiconductor portion of the body region using electron beam evaporation at a temperature between 150 to 200 °C...*", as recited in independent claim 1, from which claim 8 depends. None of the cited references suggest the use of pure single metal layers.

Appellant respectfully submits that the combination of Ma, Park, Yano and Moise, whether taken alone or in any combination, fails to describe or suggest at least the claimed feature of a "*...evaporation depositing a substantially amorphous and 0.99999 pure single element metal layer directly contacting a single crystal semiconductor portion of the body region using electron beam evaporation at a temperature between 150 to 200 °C, the metal being chosen from the group IVB elements of the periodic table; and oxidizing the metal layer using a krypton(Kr)/oxygen (O_2) mixed plasma process to form a metal oxide layer directly contacting the body region, wherein the metal oxide layer is amorphous and has a smooth surface with a surface roughness variation of 0.6 nm...*", as recited in independent claim 9. None of the cited references suggest the use of pure single metal layers.

The dependent claims are held to be patentable at least as depending from patentable base claims as shown above, since any claim depending from a nonobvious independent claim is also nonobvious. See M.P.E.P. § 2143.03. In view of the failure of the suggested combination of references to describe or suggest the above noted features, Appellant requests this rejection under 35 U.S.C. § 103(a) be reconsidered and withdrawn.

SUMMARY

For the reasons argued above, claims 1-2 and 6-9 were not properly rejected under §103(a) as being unpatentable over Ma in view of Park and Yano, and further in view of Moise.

It is respectfully submitted that the art cited does not render the claim anticipated and that the claims are patentable over the cited art. Reversal of the rejection and allowance of the pending claim are respectfully requested.

Respectfully submitted,

SCHWEGMAN, LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402

Date 9-22-08 By David Suhl
David Suhl
Reg. No. 43,169

CERTIFICATE UNDER 37 CFR 1.8: The undersigned hereby certifies that this correspondence is being filed using the USPTO's electronic filing system EFS-Web, and is addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on this 22nd day of September, 2008.

Ryan Saunders
Name

Signature

8. CLAIMS APPENDIX

1. A method of forming a gate oxide on a transistor body region, comprising:

evaporation depositing a substantially amorphous and 0.99999 pure single element metal layer directly contacting a single crystal semiconductor portion of the body region using electron beam evaporation at a temperature between 150 to 200 °C, the metal being chosen from the group IVB elements of the periodic table; and

oxidizing the metal layer to form a metal oxide layer directly contacting the body region, wherein the metal oxide layer is amorphous and has a smooth surface with a surface roughness variation of 0.6 nm.

2. The method of claim 1, wherein evaporation depositing the metal layer includes evaporation depositing a zirconium layer.

3.-5. (Canceled)

6. The method of claim 1, wherein oxidizing the metal layer includes oxidizing at a temperature of approximately 400 °C.

7. The method of claim 1, wherein oxidizing the metal layer includes oxidizing with atomic oxygen.

8. The method of claim 1, wherein oxidizing the metal layer includes oxidizing using a krypton (Kr)/oxygen (O_2) mixed plasma process.

9. A method of forming a gate oxide on a transistor body region, comprising:

evaporation depositing a substantially amorphous and 0.99999 pure single element metal layer directly contacting a single crystal semiconductor portion of the body region using electron beam evaporation at a temperature between 150 to 200 °C, the metal being chosen from the group IVB elements of the periodic table; and

oxidizing the metal layer using a krypton(Kr)/oxygen (O_2) mixed plasma process to form a metal oxide layer directly contacting the body region, wherein the metal oxide layer is amorphous and has a smooth surface with a surface roughness variation of 0.6 nm.

9. EVIDENCE APPENDIX

None.

10. RELATED PROCEEDINGS APPENDIX

None.